

Remarks

Claims 1-5, 7, and 8 are presented for the Examiner's review and consideration. In this Response, claim 1 is amended. Applicant believes the claim amendments and the accompanying remarks herein serve to clarify the present invention and are independent of patentability. No new matter has been added.

35 U.S.C. §103 Rejections

Claim 1-2, 4, and 7 were rejected under 35 U.S.C. §103(a), as being unpatentable over Kaman (U.S. 5,231,401, "Kaman") in view of Pepin (U.S. 6,320,611, "Pepin"), and claims 3 and 5 were rejected under 35 U.S.C. §103(a), as being unpatentable over Kaman and Pepin, and further in view of McIntyre (U.S. 5,589,905, "McIntyre"). For reasons set forth below, Applicant respectfully submits that these rejections should be withdrawn.

As an initial matter, it is noted that the references are described separately only to clarify the teachings of each reference. Thus, the presentation of references separately is not and should not be construed as an attempt to "argue references separately." It is further noted that to establish *prima facie* obviousness of a claimed invention, all the claim limitations must be taught or suggested by the prior art. *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). However, a simple teaching of elements is insufficient. In order to establish a proper *prima facie* case of obviousness, the prior art must also suggest the desirability of the claimed invention and/or give some reason for references to be combined. Therefore, in order to properly establish a *prima facie* case of obviousness, a rejection must not only show that all elements of the claimed invention are known or suggested in the prior art, but must also show that one of ordinary skill in the art would have some reason or motivation to put all the elements together to achieve the claimed invention.

First, it is very important to note that claim 1, as amended, relates to "an airborne long-range laser imaging system, for obtaining an image showing high-resolution details of a

specific object having dimensions in the order of several meters, **and which is located at a distance above 10Km, ...**". It should be noted that obtaining an image of such a small object from such a long range of above 10Km is very challenging, and the art has strived very much to fulfill such a task, with very little success, as at most the obtained images from the object have been of very low quality. There are several problems that until the instant invention have prohibited fulfilling this task, as follows:

The signal attenuation, signal to noise ratio, size of the object and the long range: There is a limitation to the power of the laser source at the aircraft, and obviously, there is a very large attenuation of the laser signal until reaching such a long range (of more than 10Km), hitting the object (having the size of several meters) and returning back to the aircraft sensor. Clearly, only some photons reach and hit such a small object at such a long range, and very few of the photons can arrive back at the aircraft sensor. In order to overcome this obstacle, prior art systems have increased the power of the laser source at the aircraft up to huge power levels. However, there are clearly many drawbacks involved in applying such a huge laser power level in an airborne platform. Moreover, even though such a high power of the laser source was applied, the results have been very limited in terms of the quality of the object's image. In this respect, Applicant refers to "Johnson Criteria" that define the minimum required resolution of a target located within background scenery to be detected by an observer. According to these criteria, the farther away the location of the target is, the higher a resolution is required in order for an observer to detect it. Moreover, the higher said required target resolution is, the higher a contrast between the target and the background scenery is required.

The problem of motion compensation and vibrations of the airborne platform: In addition to the foregoing problems (e.g. small object, very long range, very low level of signal to noise ratio, limitations in respect to the laser power, etc.), it is well known that the airborne platform is in continuous movement (and therefore motion compensation is necessary), and the platform also imposes significant vibration. Therefore, the very low signal to noise ratio due to operation at the limit of the laser source effective range (i.e., very few photons reach back to the aircraft sensor),

in addition to the inevitable movement and vibration of the aircraft, introduce a significant reduction in the quality of the system with respect to the object's image.

The solutions that have been proposed by the prior art:

In order to overcome the above mentioned problems, several solutions have been proposed:

Increase of the power of the laser source: As mentioned above, even though the power level has been increased to huge power levels, the prior art systems have still failed to provide satisfactory images of targets at ranges well below a distance of 10Km.

Extension of the duration of the laser pulse: Various prior art systems have tried to extend the duration of the laser pulse, therefore to obtain more returned photons at the aircraft sensor. However, this extension of the laser pulse can be done only to a certain degree, as increase of the duration beyond some level results in a significant smear of the object due to motions imparted to the system during the extended time period.

The prior art approach: All the solutions of the prior art have been designed to apply illumination over the object which extends **beyond** the borders of the object. More specifically, illumination that results with an illumination spot at the object location (i.e., close to the end of the laser range) having a size larger than the expected object size. This was carried out in all the prior art systems in order to always keep the most important asset, i.e., all the external borders (i.e., the contour) of the object within the single image, as the contrast between the object and its background scenery is the highest at those external borders, and therefore those borders are the most prominent within the scenery. The prior art assumed that operation in such a manner will provide best quality of images within the abovementioned constraints of very low signal to noise ratio. As such, formation of a mosaic was not suggested for laser based systems.

Simple trigonometry can show that in order to provide an illumination spot having a size larger than the expected object size (i.e., several meters of diameter) at the end of the laser source range (e.g., above 10Km), the width of the illumination beam must be in the order of 1-3 milliradians (of course the width of the laser beam also depends on the exact expected range and on the amount of background scenery that is desired to be included within the image). For

example, assuming a tank having a dimension of 10 meters is located 10,000 meters away from the laser source. In order to have an illumination spot at the object location which is larger than 10m of diameter, the illumination beam has to have a width of:

$$\alpha \geq \tan^{-1} \frac{10}{10000} \geq 0.9 \text{ millirad}$$

In order to capture the whole object in a single image, while also including some of the scenery within the image, the prior art has typically used 1-3 milliradians for the width of the illumination beam. The two prior art examples that are given in the instant application (the prior art examples relating to Figs. 1 and 2, see pages last par. of page 6 up to the bottom of page 8) indeed use an illumination beam having a width of 1-3 milliradians, and as mentioned, said prior art system includes the entire object within a single image capture.

The solution of the present invention: The instant invention moves away from the teachings of the prior art, by giving up the asset that the prior art has considered as the most important to keep. More specifically, the present invention suggests a significant reduction in the width of the illumination beam, to about 0.1-0.4 milliradians. By doing so, the instant invention does not follow the prior art practice that an object at such a long range cannot be detected, unless all the borders of the object are included (together with some portion of the background scenery) within a single image. This is clearly against the teaching of the prior art. By enabling a reduction in the illumination beam to about 0.1-0.4 milliradians, the instant invention enables a more concentrated beam that can reach a longer range, as compared to the prior art. The "loss" of the object borders within the single image has been compensated by the combination of the other elements of claim 1.

Kaman

In Kaman, an "airborne imaging lidar (light detection and ranging) sensor is provided which employs multiple pulsed laser transmitters, multiple gated and intensified array camera receivers, an optical scanner for increased field of regard, and a computer for system control, automatic target detection and display generation." (Abstract).

Kaman does not specifically indicate the range of his laser detection system, however, when discussing the need for a high signal to noise ratio, he in fact suggests two solutions:

Increase of the illumination output power by use of an additional amplifier: This solution is proposed by Kaman, for example in col. 6, lines 36-41, as follows:

This laser system is augmented by the addition of a second amplifier 142 which increases the output power approximately 50 percent. The use of a second amplifier 142 in each transmitter is an important feature of this invention and has the advantage of providing increased power with good mechanical, volumetric and weight efficiency.

Use of multiple laser sources: This solution is proposed by Kaman, for example in col. 5, lines 31-37, as follows:

A pair of lasers 60 and 62 are driven by laser power supply 54 so that short (approximately 10 ns) pulses of visible light are generated. (It will be appreciated that the present invention may utilize only a single laser transmitter; however, multiple lasers are preferred for increased power as will be discussed in detail hereinafter).

And also in col. 5, lines 31-37, as follows

Images from these cameras can be averaged to improve SNR and enhance the operator's ability to classify the target.

Both of said two solutions of Kaman suggest the transmission of much higher power in order to improve the signal to noise ratio. However, as said above, when dealing with a high range above 10 Km (see claim 1), these solutions are not really applicable in an airborne platform, as they require use of a huge power level in the laser source, or a multiple number of laser sources, that are impossible to carry and synchronize, situations that the present invention tries to avoid.

In any case, the width of the illumination beam of Kaman is many orders larger than the width of the beam of the present invention. While present claim 1 suggests an illumination beam of 0.1mrad to 0.4mrad, Kaman suggests illumination beams in the order of several degrees. The example of Col. 8, lines 30-41 suggests 3 variations for the half width of the laser beam (namely

A182=3.8°, A188=2.505°, and A184=3.079°). Inspection of Fig. 11 confirms that this width is in fact half of the width of the beam. Therefore, even in his most concentrated version of the beam, Kaman clearly suggests a beam width of 5.01° (i.e., 0.087 radians) which is 217 times larger than the largest beam width (0.4 mrad) of claim 1 (or about 870 times larger than the narrowest beam width of 0.1 mrad of claim 1). Therefore, Kaman's system is clearly designed for a short range (up to several hundreds of meters), and is inapplicable for the recognition of an object having a dimension in the order of several meters at a long range above 10 km, as in the present invention, unless an increase of the power of 217^2 or 870^2 is provided compared to the solution of the present invention (as the illumination power at the target squarely depends on the width of the beam). The fact that Kaman suggests such an increase of the beam width shows that he also teaches away from the present invention.

In any case, Fig. 1 of Kaman clearly shows that the illumination spot of Kaman covers an area which is many times larger than the expected size of the target 20. Kaman never suggests the possibility in which the width of the illumination beam "... *produces an illumination spot that covers only a portion of said object having dimensions of up to several meters and located at a long range of above 10Km*" as in claim 1 of the present invention. The Examiner is accurate in stating that the system of Kaman "*scan[s] a relatively narrow IFOV over a much larger field of regard*". However, there is no teaching in Kaman to the fact that the width of the laser beam is designed to form an illumination spot which is smaller than the outline (contour) of the target. Applicant believes that the Examiner interpretation that "...*the width of the beam is a design parameter to resolve the image at a desired distance...*" may be accurate when dealing with conventional ranges as long as the width covers the entire target, but when increasing the range to above 10Km, the suggestion of claim 1 of the present invention is in fact against the teaching of the prior art, as it suggests giving up of the outline borders of the target. As previously noted, the conventional prior art systems for such a range of above 10 Km typically use a width of 1-3 milliradians for the illumination beam (excluding Kaman that as said teaches an illumination beam which is hundreds of times wider than of the invention) in order to maintain the contour lines of the entire object within a single image, namely in order to meet the requirements of

Johnson's criteria (mentioned above), that state that the contrast of the object at the contour lines is the highest. In contrary, the present invention teach away from this approach, resulting in a much narrower illumination beam of 0.1 to 0.4 milliradians giving up these contour lines for the purpose of significantly increasing the range.

Further, Kaman does not suggest or teach, at least, and as noted in the rejection, elements (g) and (h) of claim 1, including “correlating” and “combining” units.

Pepin

Pepin discloses a “high speed detection matrix and a particular electronic processing of video signals is used to reconstruct a scan image from elementary images which have a high degree of overlap and are offset due to scan residual. ...A correlation processor delivers an offset signal for the current image to an image reconstruction processor which also receives luminance values for the current images. An image patch memory is reconstructed in which the elementary images are realigned.” (Abstract).

Initially, the system of Pepin relates to "optronic equipment", and there is no mention whatsoever of a laser beam in Pepin. Therefore, Applicant respectfully submits that Pepin is non-analogous.

Pepin is cited in the rejection for disclosing correlating images and finding similarity between features of overlapping portions. However, Applicant strongly believes that such a correlation of images may be common in the situation that Pepin has faced, but is not obvious in the situation of the present invention which is entirely different (laser beam, imaging of an object at a range above 10Km, and particularly while "scarifying" the contour lines of the object, that as said are the most important factor that allows recognition of the object).

These and other points are clarified and supported in a Rule 132 Declaration, filed together herewith, of Yitzhak Nevo, Ph.D.

McIntyre is cited for disclosing that a “scan rate is inversely proportional to the range to the distance to the object”. McIntyre discloses “Generally, the beam scan rate is decreased as the

distance to the object 29 and ambient light level increase, thereby allowing the light beam to have a longer dwell time at each point about the frame. As such, the perceived brightness by the camera user will remain essentially constant irrespective 55 of object-camera distance and/or ambient light level. Under some conditions, however, the framing aid 39 might not be readily visible on an object 29 regardless of the distance. For example, the ambient light level might be so great that the ambient light will overwhelm the framing aid and prevent 60 the framing aid from being visible about the object at any useful camera-to-object distance.” (C4L-61).

Thus, McIntyre is directed to maintaining the light intensity of a framing aid, and is not directed to subject matter analogous to the instant invention. Accordingly McIntyre does not correct the deficiencies of Kaman and Pepin, as detailed above.

Accordingly, Applicant respectfully submits that claim 1 is patentable over a combination of Kaman, Pepin, and McIntyre. As claims 2-5 and 7 depend from claim 1, these dependent claims necessarily include all the elements of their base claim. Accordingly, Applicant respectfully submits that the dependent claims are allowable over the cited references for at least the same reasons.

In light of the foregoing, Applicant respectfully requests reconsideration and withdrawal of the §103 rejection.

Conclusion

In light of the foregoing remarks, this application is now in condition for allowance and early passage of this case to issue is respectfully requested. If any questions remain regarding this amendment or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

A fee of \$1270 for a three month extension is believed to be due, and is being paid together herewith. However, please charge any other required fee (or credit overpayments) to the Deposit Account of the undersigned, Account No. 500601 (Docket No. 7640-X06-062)

Respectfully submitted,

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